

Efficiency and price clustering in Islamic stocks: evidence from three Asian countries

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136

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Abstract

Purpose – This paper aims to examine the extent of price clustering in a selection of Islamic stocks listed in Indonesia, Malaysia and Pakistan and also investigates the determinants of the phenomenon at the firm level.

Design/methodology/approach – The author test the uniformity of price distribution in the selected securities. Then, the determinants of price clustering were investigated through multivariate analysis based on a binary logistic regression model. Following the arguments of Narayan *et al.* (2011), who emphasize the importance of considering firm heterogeneity when studying the phenomenon, the author conducts the empirical study at the firm level.

Findings – The evidence indicates that Islamic stocks show a mild level of price clustering. Only half of the stocks under analysis rejected the uniformity test in the distribution of prices. In these cases, investors exhibited a preference for prices ending at zero and five. The evidence does not confirm the cultural clustering theories. Price clustering is found to be positively associated with price level and relative bid-ask spread. Overall, the negotiation hypothesis, which predicts that investors prefer round prices to minimize the costs associated with negotiations, best explains most of our results.

Research limitations/implications – The existence of price clustering is difficult to reconcile with the prediction of the efficient market hypothesis that prices should follow a random walk. Moreover, the evidence indicates that Muslim investors share a preference for round prices in some settings, under the assumption that Islamic stocks are mostly traded by Muslim investors.

Originality/value – To the author's best knowledge, this is the first study to address the subject of price clustering in Islamic stocks.

Keywords Price clustering, Islamic stocks, Stock market efficiency, Indonesia, Malaysia, Pakistan

Paper type Research paper

1. Introduction

Capital markets play an important role in modern economies. By facilitating the raising and allocation of capital by public companies, in theory they contribute to promote economic growth and the creation of wealth. The positive impact of well-functioning capital markets on economic growth has been confirmed empirically in international markets (King and Levine, 1993; Wurgler, 2000; Rajabi and Muhammad, 2014). However, the influence of



behavioral biases and other frictions, by distorting financial prices, can hamper the proper functioning of capital markets, causing poor capital allocation decisions (Korniotis and Kumar, 2011; Shiller, 2016). Therefore, studying the behavioral factors that may affect the efficiency of capital markets is of great importance.

In this paper, we examine the phenomenon of price clustering, which is the tendency for prices to accumulate at certain numbers, in a set of 12 large Islamic stocks traded in three mostly Muslim countries (Indonesia, Malaysia and Pakistan). To the best of our knowledge, this is the first time that price clustering is investigated in the context of Islamic stocks.

The choice of the countries under study was motivated by the existence of important Islamic indices on the respective stock exchanges and by the high percentage of the population that claims to profess the Islamic religion. In fact, according to estimates, 87.2%, 63.7% and 96.4% of the populations of Indonesia, Malaysia and Pakistan, respectively, declare to follow this religion (Pew Research Center, 2012).

Price clustering resulting from the preference of investors for round numbers is usually considered to be at odds with the most widely used benchmark to assess the proper functioning of capital markets, the efficient market hypothesis (EMH) (Samuelson, 1965; Fama, 1970). In fact, the EMH posits that financial prices reflect all available information, and so the price of a security should be a good estimate of its intrinsic value. Because there is no reason why the intrinsic value of stocks, measured by the discounted value of future cash flows, would relatively often be a round number, the presence of price clustering seems to put into question the EMH (Niederhoffer, 1965; De Grauwe and Decupere, 1992). As stated by Thaler (1992, p. 138), in an efficient market, “no one would choose the most popular numbers.”

However, the empirical literature suggests that price clustering is pervasive in stock markets (Aitken *et al.*, 1996; Ikenberry and Weston, 2008; Narayan *et al.*, 2011). In many circumstances, investors prefer to trade at round prices to minimize cognitive and/or economic costs (Ball *et al.*, 1985; Goodhart and Curcio, 1991; Harris, 1991; Mitchell, 2001) and also exhibit a tendency to prefer prices ending in digits that have an especially positive symbolism in the context of their culture (Brown *et al.*, 2002; Cai *et al.*, 2007; Wagner and Jamsawang, 2014). Price clustering contributes to increase the predictability of stock prices and can be used to conceive profitable trading strategies (Niederhoffer, 1965; Bhattacharya *et al.*, 2012; Blau *et al.*, 2020).

Islamic investments are reportedly the fastest-growing segment of the global financial industry. Global Islamic financial assets reached the staggering amount of 2.88tn US\$ in 2020 and are expected to rise to 3.69tn US\$ by 2024 (Islamic Corporation for the Development of the Private Sector (ICD) and Refinitiv, 2021). However, the way “emotions, irrational behavior and biases drive [Islamic] share prices” have been largely ignored by the academic literature (Hassan *et al.*, 2021, p. 1283).

Our empirical strategy begins with a test of the price distribution uniformity in the selected securities. Then, the determinants of price clustering are investigated through a multivariate analysis based on a binary logistic regression model. Following the arguments of Narayan *et al.* (2011) that highlight the importance of considering firm heterogeneity when studying stock price clustering, we conduct our empirical study at the firm level.

The evidence indicates that Islamic stocks showed a mild level of price clustering. In fact, of the 12 stocks analyzed, only half of them (two of the stocks traded in Indonesia and the four stocks traded in Malaysia) rejected the test of uniformity in the distribution of prices. For the first time, we show that cultural clustering theories, which posit a higher prevalence of prices ending in digit seven in countries of Islamic culture, are not confirmed by evidence.

The negotiation hypothesis, which predicts that investors prefer round prices to minimize the costs associated with negotiations, best explains most of our results.

Our paper makes several contributions to the literature. First, the current study is the first to address the topic of price clustering in the context of Islamic stock markets. This is of special importance given the growing economic importance of these markets and the relative scarcity of information on the behavioral patterns exhibited by Muslim investors. A second contribution is that, unlike most of the studies on the topic of price clustering, we do not examine the phenomenon for the aggregate market. Rather, we adopt a micro-level approach to investigate price clustering and its determinants at a firm level, which enables us to take into account the heterogeneity of the firms included in our sample. Finally, we are the first to test cultural theories of price clustering in the case of securities that are traded in an Islamic cultural setting.

The remainder of the paper is organized as follows. In the next section, we conduct a brief review of the related literature. Section 3 presents the data and the methodology adopted in the empirical study. In Section 4, we discuss the results. Section 5 concludes the paper and presents suggestions for further research.

2. Literature review

2.1 Behavioral patterns of investors in Islamic stocks

As pointed out by [Hassan et al. \(2021\)](#), the evidence on the behavioral patterns exhibited by investors that trade Islamic stocks is rather scarce. Some studies analyze the influence of investor sentiment on their decisions and on the evolution of Islamic stock prices. For example, [Rashid et al. \(2014\)](#) examined this issue in the Islamic stock price index in Malaysia, concluding that sentiment indicators significantly influenced the index, although the impact of macroeconomic factors such as interest rates and exchange rates was even more significant. [Aloui et al. \(2016\)](#) confirmed the impact of sentiment on Islamic stock indices present in US markets. [Jaziri and Abdelhedi \(2018\)](#) investigated whether the Islamic religious occasions could, through their impact on investor sentiment, affect returns in six Arab financial markets (Saudi Arabia, Dubai, Kuwait, Egypt, Qatar and Bahrain). The authors conclude that the Hajj pilgrimage, Ramadan and Eid-al-Fitr significantly influenced the relationship between investor sentiment and returns. More recently, [Danila et al. \(2021\)](#) examined the impact of market sentiment shocks on the volatility of the Islamic stock index of five ASEAN countries (Indonesia, Malaysia, Thailand, the Philippines and Singapore) to conclude that that impact was significant in the Indonesian and Malaysian markets, which are the two largest Islamic markets with a dominant Muslim population in the ASEAN.

Other studies scrutinize the existence of herding behavior in the context of Shariah-based ethical investments. For example, [Stavroyiannis and Babalos \(2017\)](#) analyzed the constituent stocks of the Dow Jones Islamic Index to document that investors exhibited a significant antihherding behavior, especially during turbulent periods. [Chaffai and Medhioub \(2018\)](#) studied the topic in the stock markets of the Islamic Gulf Cooperation Council (GCC), finding significant evidence of herding behavior, particularly during rising markets. [Mnif et al. \(2020\)](#) examined the Dow Jones Islamic Market and the Sukuk market in comparison to the Dow Jones Sustainability Index and the standard Dow Jones Industrial Average. The authors document that herding behavior was more intense in the Islamic stock market and that it did not exist at a significant level in the Sukuk market. [Mand et al. \(2021\)](#) found that herding behavior among investors in Sharia-compliant stocks was present during up and down markets in Malaysia. Recurring to a questionnaire collected from 410 respondents in Pakistan, [Din et al. \(2021\)](#) showed that behavioral biases such as self-attribution, illusion of control and information availability exerted a positive and significant impact on herding for

Islamic financial products. Recently, [Bougatef and Nejah \(2022\)](#) attributed the formation of herd behavior among investors in Shariah-compliant stocks belonging to the Dow Jones Islamic Market Malaysia Titans 25 Index to the COVID-19 pandemic.

There are also studies that look into specific behavioral biases and their impact on financial prices. For example, [Shah et al. \(2018\)](#) show through a study based on questionnaires that investors trading in the Pakistani stock market were significantly influenced by biases such as overconfidence, representativeness bias and anchoring bias. Further, [Cheema and Nartea \(2018\)](#) document that there is no significant difference in momentum returns between Islamic and non-Islamic stocks, which they ascribe to the existence of overconfident investors in those markets. More recently, [Chaffai and Medhioub \(2020\)](#) explored the prevalence of the anchoring bias of Muslim investors in the Islamic GCC stock markets. The main conclusion is that investors were significantly influenced by that bias, i.e. they tended to rely too heavily on a single piece of information when making decisions.

Overall, most studies that compare Islamic and conventional stock markets have suggested similarities among these markets.

The literature on the behavior of investors in Shariah-compliant stocks does not include, to the best of our knowledge, any study on the prevalence and determinants of price clustering. The current study fills this gap.

2.2 Price clustering

Our paper also adds to the literature on stock price clustering. The initial empirical evidence regarding the clustering of stock prices was presented about 50 years ago by [Osborne \(1962\)](#) and [Niederhoffer \(1965\)](#). Closing stock prices have been found to cluster in the US ([Harris, 1991](#); [Ikenberry and Weston, 2008](#)) as well as in other international stock markets including Australia ([Aitken et al., 1996](#)), Canada ([Capelle-Blancard and Chaudhury, 2007](#)), China ([Cai et al., 2007](#); [Brown and Mitchell, 2008](#); [Hu et al., 2017](#)), Mexico ([Narayan et al., 2011](#)), Fiji Islands ([Narayan and Smyth, 2013](#)), Singapore ([Hameed and Terry, 1998](#)), the Netherlands ([Sonnemans, 2006](#)) and the Baltic states ([Lobão, 2022](#)).

Moreover, empirical evidence indicates that prices tend to cluster on round increments in other assets besides stocks, such as bonds ([Ap Gwilym et al., 1998](#)), futures and options ([Ni et al., 2005](#); [Chung and Chiang, 2006](#)), exchange rates ([Sopranzetti and Datar, 2002](#); [Mitchell and Izan, 2006](#)), crude oil ([Dowling et al., 2016](#); [Narayan, 2022](#)), betting markets ([Brown and Yang, 2016](#)), electricity markets ([Lobão and Pinto, 2021](#)) and cryptocurrencies ([Urquhart, 2017](#); [Xin et al., 2020](#)).

The price resolution hypothesis ([Ball et al., 1985](#)), the negotiation hypothesis ([Harris, 1991](#)), the attraction hypothesis ([Gottlieb and Kalay, 1985](#); [Goodhart and Curcio, 1991](#)) and the cultural hypothesis ([Brown et al., 2002](#); [Cai et al. \(2007\)](#)) are the main explanations of stock price clustering. The price resolution hypothesis and the negotiation hypothesis rest essentially on arguments of economic nature. The price resolution hypothesis suggests that price clustering results from the achievement of the optimal level of price resolution, i.e. the desired degree of price accuracy. A coarser price resolution due to the lack of information about the underlying value of a security induces traders to submit orders at round-numbered prices to minimize overall search costs. Thus, for example, when the return volatility is higher reflecting the higher uncertainty felt by investors, the price resolution hypothesis predicts that investors will be more willing to trade at round prices.

The negotiation hypothesis is based on the idea that price clustering occurs because traders, when trying to reduce the costs of negotiating, use a restricted set of prices to specify the terms of their trades. As a result, when the costs of negotiation are higher, there

should be more price clustering. For example, situations where the bid-ask spread is higher should encourage clustering.

According to the attraction hypothesis, some prices such as those ending in zero and also in five are psychologically more appealing because in the decimal system they are easier to recall. The least common digit should be one and nine.

Finally, authors such as [Brown et al. \(2002\)](#) and [Cai et al. \(2007\)](#) argue that cultural factors can play a relevant role in the phenomenon of price clustering. For example, it is asserted that because the digit eight represents good luck in Chinese culture, eight-ending prices should be more popular in markets under the influence of this culture. Likewise, it is to be expected that digit four, as it is not appreciated in the context of the Chinese culture, will be less frequent in prices. [Wagner and Jamsawang \(2014\)](#) contend that the digit seven has a prominent place in Islamic culture. It is considered to be a sacred number, playing an important religious role. For example, the pilgrims to Mecca must proclaim *Allahu Akbar* (“God is greater”) and the creed seven times; the Koran describes seven heavens, seven earths and seven oceans; and, during prayer, seven parts of the body must touch the ground ([Schimmel, 1993](#); [Wagner and Jamsawang, 2014](#)). Consistent with their predictions, [Wagner and Jamsawang \(2014\)](#) find that number seven is more common in restaurant prices in Islamic settings.

The main theories of price clustering are summarized in [Table 1](#).

To the best of our knowledge, no study has yet addressed the validity of cultural theories of price clustering in the context of Islamic stocks. The present study fills this research gap.

3. Data and methodology

As our analysis focuses on the price clustering of Islamic stocks, we started by selecting all the stocks that, as of December 31, 2021, belonged to each of the major Islamic indices of Indonesia (Jakarta Stock Exchange Islamic Index), Malaysia (FTSE Bursa Malaysia Hijra Sharia Index) and Pakistan (Pakistan Mezan Islamic Index). The choice of these countries was motivated by the high percentage of the respective populations that claim to profess the Islamic religion. We downloaded the daily closing prices of these stocks for the sample period January 1, 2013 –December 31, 2021 from Datastream by Refinitiv. We excluded the prices observed in periods during which the stock did not belong to the Islamic index. Further, since the tick size of the constituents of the Jakarta Stock Exchange Islamic index and of the FTSE Bursa Malaysia Hijra Sharia Index varies depending on the asset’s price

Name	Nature of the theory	Explanation for the preference of certain numbers in financial prices	References
Resolution hypothesis	Economic	Investors prefer round prices because they are unsure about the asset’s true fundamental value	Ball et al. (1985)
Negotiation hypothesis	Economic	Investors prefer round prices to minimize the costs associated with negotiations	Harris (1991)
Attraction hypothesis	Cognitive	Investors prefer round prices to minimize cognitive processing costs	Gottlieb and Kalay (1985) , Goodhart and Curcio (1991)
Cultural hypothesis	Cultural	Investors prefer numbers that have a especially positive symbolism in their culture	Brown et al. (2002) , Cai et al. (2007) , Wagner and Jamsawang (2014)

Table 1.
Theories of price clustering

Source: Own elaboration

range, and taking into account that our objective is to study the (lack of) uniformity in the distribution of the last digit of prices in the 0–9 range, we removed the prices formed with a tick size other than one ringgit and one rupiah in the case of the stocks belonging to the Malaysian index and to the Indonesian index, respectively. For example, we excluded prices with a tick size of five rupiahs because that tick size prevents the occurrence of prices ending in 1-4 and 6–9. Finally, we retained the stocks with the highest market capitalization in each of the three Islamic indexes provided that those stocks had been traded for at least 900 trading sessions between January 1, 2013 and December 31, 2021.

The application of these criteria led to the selection of the following 12 securities: Telekomunikasi Indonesia, Vale Indonesia, Bukit Asam and Bumi Resources from Indonesia; Petronas Chemicals Group, Press Metal Aluminium Holdings, Sime Darby Plantation and IHH Healthcare from Malaysia; and Oil & Gas Development Company, Mari Petroleum Company, Lucky Cement and Pakistan Petroleum from Pakistan. Finally, the daily turnover and the bid-ask spread at the end of the trading day of these 12 securities for the period January 1, 2013 –December 31, 2021 were also extracted from Datastream by Refinitiv.

The companies of Indonesia, Malaysia and Pakistan of our sample represent, respectively, 34.5%, 27.6% and 42.6% of the market capitalization as of December 31, 2021 of the Islamic indices to which they belong.

Table 2 summarizes the data on the selected companies, including some basic statistics such as the mean, standard deviation and maximum and minimum stock prices for each of the nine companies.

Our study on price clustering starts with the examination of the frequency of the last digit of the closing stock price between zero and nine. If price clustering does not exist in the sample, each of the last possible digits (0–9) should be observed about 10% of the time.

Then, to scrutinize the determinants of price clustering, the following binomial logistic regression model was run for each of the securities under analysis that exhibited a significant accumulation of prices at digit zero:

$$PC_t = \alpha + \beta_1 Price_t + \beta_2 Turnover_t + \beta_3 Volatility_t + \beta_4 Spread_t + e_t \quad (1)$$

where:

PC_t = binary variable, which takes the value 1 if the last digit of the closing price in day t is zero and 0 otherwise;

$Price_t$ = natural log of the closing price in day t ;

$Turnover_t$ = natural log of the number of stocks traded in day t (in thousands) scaled by the number of outstanding shares;

$Volatility_t$ = natural log of the standard deviation of stock daily returns in the previous five days; and

$Spread_t$ = natural log of the relative bid-ask spread in day t , where the relative bid-ask spread is defined as the difference between the ask price and the bid price at the end of the trading day scaled by the midpoint of the ask and bid price.

Following the literature on the topic (Aitken *et al.*, 1996; Brown *et al.*, 2002), the standard definition of price clustering, which captures the tendency of prices to cluster at zero ahead of 1–9, is adopted in our study as the dependent variable of the regression.

The choice of the independent variables introduced in our model is motivated by the resolution hypothesis and negotiation hypothesis and is generally supported in the literature on the topic. The price level is usually included as a regressor since a given price variation represents a smaller fraction of the price for high-priced stocks than for low-priced stocks.

Table 2.
Companies selected
for the univariate
analysis

Companies	Country	Industry	Sector	Obs	Descriptive statistics of the price level series				
					Mean	Std	Max	Min	
Telekomunikasi Indonesia	Indonesia	Telecommunications	Telecommunications service providers	1,377	3785.90	466.02	4800.00	2560.00	
Vale Indonesia	Indonesia	Basic materials	Precious metals and mining	1,175	3383.51	724.60	4980.00	1950.00	
Bukit Asam	Indonesia	Energy	Oil, gas and coal	926	2956.76	791.99	4890.00	2000.00	
Bumi Resources	Indonesia	Energy	Oil, gas and coal	934	100.68	43.42	200.00	50.00	
Petronas Chemical Group	Malaysia	Basic Materials	Chemicals	2,208	5.46	0.86	7.34	3.21	
Press Metal Aluminium Hold.	Malaysia	Basic Materials	Industrial metals and mining	2,208	7.12	1.06	9.70	4.11	
Sime Darby Plantation	Malaysia	Consumer Staples	Food producers	2,188	3.99	1.68	10.80	1.48	
IHH Healthcare	Malaysia	Health Care	Health care providers	1,000	4.89	0.51	6.00	3.30	
Oil & Gas Development Comp.	Pakistan	Energy	Oil, gas and coal	2,230	159.57	52.70	287.84	75.01	
Mari Petroleum Comp.	Pakistan	Energy	Oil, gas and coal	2,230	985.16	521.46	1809.41	90.06	
Lucky Cement	Pakistan	Industrials	Construction and materials	2,230	529.40	191.87	994.65	146.19	
Pakistan Petroleum	Estonia	Energy	Oil, gas and coal	2,199	159.40	47.68	260.06	69.13	

Source: DataStream by Refinitiv and own elaboration

Thus, when dealing with higher stock prices, investors are expected to be more likely to round them (Harris, 1991; Hameed and Terry, 1998). Market-wide studies on price clustering suggest the existence of a positive relationship between the phenomenon and price level (Harris, 1991; Aitken *et al.*, 1996; Hameed and Terry, 1998; Hu *et al.*, 2017).

According to the resolution hypothesis, price clustering should increase with uncertainty in security pricing. Thus, price clustering is expected to exhibit a negative relationship with liquidity and a positive relationship with return volatility. Higher liquidity is likely to contribute to the reduction of information asymmetry among investors and to lower the levels of market uncertainty, encouraging investors to use a finer price grid. The liquidity of each security is captured in our study by the turnover. A negative association between liquidity and price clustering has been observed in the literature (Brown *et al.*, 2002; Ikenberry and Weston, 2008).

Following Harris (1991), the volatility of each security is proxied in our study by the standard deviation of the previous five days' daily returns. In theory, return volatility is understood to reflect the level of uncertainty about a security's fundamental value. In periods of intense volatility, one should expect investors to round their valuations and place orders quickly in order to avoid unfavorable price changes. As such, volatility should bear a positive relationship with price clustering. However, the evidence on the empirical relationship between return volatility and price clustering is mixed: while some authors report a positive impact of volatility on the phenomenon (Aitken *et al.*, 1996; Hu and Wu, 2006), other studies find a negative relationship between return volatility and clustering (Brown and Mitchell, 2008; Narayan *et al.*, 2011) or no significant relationship between the variables (Hameed and Terry, 1998; Ikenberry and Weston, 2008).

According to the negotiation hypothesis, the higher the transaction costs, the higher should be the prevalence of price clustering (Harris, 1991). The costs of trading are proxied in our study by the relative bid-ask spread.

Each independent variable is natural log-transformed to achieve normal distribution.

4. Results and discussion

4.1 Detection of price clustering

Tables 3–5 report the frequency distribution of the digits of daily closing prices of the 12 securities under analysis.

The Chi-square test rejects the hypothesis of a uniform distribution of the clustering digit at the statistical level of 5% only in six of the 12 stocks: Telekomunikasi Indonesia and Bumi Resources from Indonesia; and all the stocks traded in Malaysia. In these cases, the frequency distribution is shown to be significantly different from the uniform distribution that would be expected to be observed if prices were randomly selected. Two Indonesian stocks (Vale Indonesia and Bukit Asam), as well as all stocks traded in Pakistan, showed no signs of lack of uniformity in the price distribution.

In the cases where price uniformity is rejected, daily closing prices tend to cluster at digit zero. The accumulation of prices in this digit ranged from 12.85% (Telekomunikasi Indonesia) to 20.61% (Press Metal Aluminium Holding) when one would expect to observe frequencies around 10% if prices were evenly distributed. In the remaining cases, the percentage of prices in these stocks varied from 9.51% to 12.53%. These frequencies compare, for example, with 13.70%, 16.50% and 26.6% obtained in similar studies conducted by Brown *et al.* (2002), Narayan and Smyth (2013) and Aitken *et al.* (1996) in the stock markets of Hong Kong, the Fiji Islands and Australia, respectively. In a study conducted at a firm level by Narayan *et al.* (2011) in the Mexican stock market, the authors report that eight of the 12 stocks under study exhibited signs of abnormal accumulation of prices at digit zero. The stocks in this situation presented a percentage of prices ending on

Table 3.
Relative frequency
with which daily
closing prices of
Islamic stocks issued
in Indonesia
clustered on each
digit

Digit	Telekomunikasi Indonesia		Vale Indonesia		Bukit Asam		Bumi resources	
	Freq. (%)	z-stat.	Freq. (%)	z-stat.	Freq. (%)	z-stat.	Freq. (%)	z-stat.
0	12.85	2.354**	11.06	0.840	12.53	1.720*	14.99	3.261***
1	8.50	-1.362	9.36	-0.523	9.18	-0.600	10.60	0.426
2	8.64	-1.226	9.28	-0.594	8.96	-0.761	10.06	0.046
3	8.93	-0.957	9.36	-0.523	9.50	-0.360	10.60	0.426
4	8.79	-1.091	8.85	-0.953	10.69	0.488	8.78	-0.904
5	11.55	1.309	12.43	1.863*	10.91	0.638	8.78	-0.904
6	9.88	-0.108	9.36	-0.523	9.29	-0.520	7.92	-1.571
7	11.04	0.888	10.72	0.575	8.21	-1.341	9.64	-0.264
8	9.51	-0.430	9.62	-0.312	11.45	1.006	8.57	-1.068
9	10.31	0.271	9.96	-0.034	9.29	-0.520	10.06	0.046
0+5	24.40	2.779***	23.49	2.050**	23.43	2.192*	23.77	1.970**
Even digits	49.67	-0.171	48.17	-0.887	52.92	1.255	50.32	0.139
Chi-square stat.		25.723		12.634		14.820		32.788
p-value		0.002267		0.179876		0.095979		0.000145
(Chi-square test)								

Notes: *Significance at the 10% level; **significance at the 5% level; ***significance at the 1% level
Source: Own elaboration

Table 4.
Relative frequency
with which daily
closing prices of
Islamic stocks issued
in Malaysia clustered
on each digit

Digit	Petronas chemical group		Press metal aluminium hold.		Sime darby plantation		IHH healthcare	
	Freq. (%)	z-stat.	Freq. (%)	z-stat.	Freq. (%)	z-stat.	Freq. (%)	z-stat.
0	19.79	9.138***	20.61	9.789***	17.28	7.012***	16.20	4.109***
1	7.70	-2.692***	9.01	-1.118	8.04	-2.258**	9.60	-0.301
2	7.70	-2.692***	7.65	-2.748***	7.77	-2.593***	7.00	-2.405**
3	7.61	-2.804***	7.65	-2.748***	9.05	-1.071	7.90	-1.645*
4	7.79	-2.580***	8.24	-2.028**	8.23	-2.038**	8.60	-1.078
5	12.32	2.447**	14.13	4.213***	12.80	2.911***	14.60	3.132***
6	9.42	-0.651	7.84	-2.524**	8.87	-1.283	10.10	0.074
7	7.65	-2.748***	6.43	-4.318***	8.55	-1.657*	8.40	-1.238
8	9.47	-0.599	9.69	-0.343	10.01	0.010	10.10	0.074
9	10.55	0.605	8.74	-1.436	9.41	-0.654	7.50	-1.978**
0+5	32.11	9.167***	34.74	10.983***	30.07	7.691***	30.80	5.548***
Even digits	54.17	2.771***	54.03	2.681***	52.15	1.421	52.00	0.895
Chi-square stat.		284.554		361.538		169.248		83.960
p-value		<0.000001		<0.000001		<0.000001		<0.000001
(Chi-square test)								

Notes: *Significance at the 10% level; **significance at the 5% level; ***significance at the 1% level
Source: Own elaboration

that digit ranging from 12.4% to 44.1%, which indicates that the prevalence of price clustering observed in our sample was less pronounced.

Our results suggest that local factors, related to the national market in which the stocks are traded, may be important in the prevalence of clustering in addition to the specific characteristics of the companies under study. To examine this point, it is interesting to

Table 5.

Relative frequency with which daily closing prices of Islamic stocks issued in Pakistan clustered on each digit

Digit	Oil & gas development comp.		Mari petroleum comp.		Lucky cement		Pakistan petroleum	
	Freq.(%)	z-stat.	Freq.(%)	z-stat.	Freq.(%)	z-stat.	Freq.(%)	z-stat.
0	10.22	0.248	11.61	1.736*	9.51	-0.555	10.82	0.894
1	10.45	0.494	8.79	-1.386	10.81	0.883	9.60	-0.451
2	10.09	0.100	9.46	-0.606	10.40	0.445	9.60	-0.451
3	9.06	-1.071	10.58	0.641	9.46	-0.606	10.32	0.354
4	10.72	0.786	9.55	-0.504	10.45	0.494	9.73	-0.298
5	10.13	0.149	10.22	0.248	10.54	0.592	9.78	-0.248
6	9.69	-0.352	9.28	-0.812	10.18	0.199	10.32	0.354
7	10.04	0.050	10.45	0.494	8.30	-1.974**	9.00	-1.126
8	9.64	-0.403	10.85	0.931	10.18	0.199	10.91	0.990
9	9.96	-0.050	9.19	-0.915	10.18	0.199	9.91	-0.096
0+5	20.36	0.298	21.84	1.509	20.04	0.037	20.60	0.495
Even digits	50.36	0.240	50.76	0.509	50.72	0.479	51.39	0.920
Chi-square stat.	4.260		15.713		10.789		6.971	
p-value (Chi-square test)	0.893475		0.073122		0.290432		0.640149	

Notes: *Significance at the 10% level; ** significance at the 5% level
Source: Own elaboration

observe the evolution of price clustering over time in the stocks belonging to each country. Figure 1 depicts the percentage of prices ending in zero in each of the national stock markets, aggregating the data of the respective stocks over time.

Figure 1 shows that the phenomenon of price presented quite different dynamics over time in the three countries considered in the sample. As expected, stocks traded in Pakistan showed the lowest level of clustering, consistent with a higher level of informational price efficiency. In the initial part of the sample, the percentage of prices ending in zero was in fact

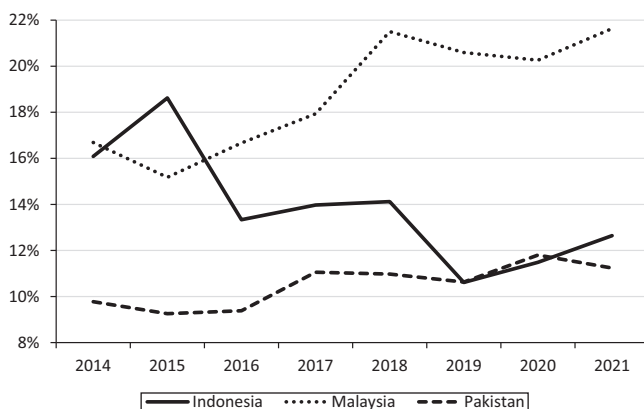


Figure 1. Price clustering in digit zero in selected Islamic stocks from Indonesia, Malaysia and Pakistan

Notes: The figure depicts the percentage of prices ending in zero in each national stock market considering the selection of stocks listed in the respective Islamic stock index
Source: Own elaboration

lower than 10%, with a slight tendency towards an increase in the prevalence of the phenomenon over time. The Islamic stocks traded in Indonesia exhibited a moderate level of price clustering. There is a downward trend in the magnitude of the phenomenon, which is consistent with the idea that the market is becoming more efficient over time. Finally, the stocks listed in Malaysia present the highest levels of clustering throughout the sample period. Furthermore, the intensity of price clustering seems to have increased over time: in the last years of the sample, the frequency of prices ending in zero was above 20%, which indicates that the market has become less efficient over the sample period.

4.2 Determinants of price clustering

According to the attraction hypothesis (Gottlieb and Kalay, 1985; Goodhart and Curcio, 1991), digit five should be the strongest attractor right after the digit zero, and prices ending in one and nine should be the least common. In fact, in five of the six stocks whose prices do not follow the uniform distribution, prices ending in five are the second most frequent (Bumi Resources is the exception). However, the prediction that prices ending in one and nine should be the least frequent is not verified in our sample. Prices ending in one are the least observed only in the case of Telekomunikasi Indonesia stocks, and there is no single stock where nine is the last digit of least common prices. In conclusion, the attraction hypothesis provides only a partial explanation for the observed results.

The cultural theories of price clustering (Brown *et al.*, 2002; Cai *et al.*, 2007; Wagner and Jamsawang, 2014) posit that the digit seven has a particular symbolism in Islamic contexts. Therefore, one should expect to observe prices ending in that digit more often than would occur if prices followed a uniform distribution. However, the data in Tables 3–5 do not support this prediction. In fact, the results reveal that prices ending in seven were not unusually frequent in the stocks of the sample. Given the very significant prevalence of round prices in the stocks listed in Malaysia, prices ending in digit seven were even abnormally rare in three of the stocks of that country (statistically significant results at the 10% level).

Our study proceeds with the examination of the determinants of price clustering, considering the predictions of the resolution and negotiation hypotheses. The results of the binary logistic regression model (1) for each of the six securities for which we found evidence of excessive accumulation of prices on digit zero (Vale Indonesia, Bukit Asam, Oil & Gas Development Company, Mari Petroleum Company, Lucky Cement and Pakistan Petroleum were excluded) are shown in Table 6.

The predictive accuracy of the model, measured by the percentage of prices classified correctly as clustered or not clustered, ranges from 79.4% to 87.0%. These figures are relatively high and are similar to those found in similar studies (Aitken *et al.*, 1996).

Our results show that a higher price level was associated with a statistically significant increase in the likelihood of price clustering in four of the securities under analysis (Telekomunikasi Indonesia, Bumi Resources, Petronas Chemical Group and Sime Darby Plantation). This result is consistent with the price negotiation/resolution hypotheses and goes in accordance with most of the contributions in the field (Harris, 1991; Aitken *et al.*, 1996; Hameed and Terry, 1998; Brown *et al.*, 2002; Hu *et al.*, 2017).

In general, the impact of the independent variable turnover on the propensity of prices to cluster at round numbers is not significant. The stocks issued by IHH Healthcare are the exception, but the coefficient has a sign opposite to that predicted by the resolution hypothesis.

The volatility variable exerted a statistically significant effect on the likelihood of observing price clustering in four of the six securities. In the case of Petronas Chemical Group and Press Metal Aluminium Holding, the impact is significantly positive, but in the case of Bumi Resources and Sime Darby Plantation, the effect is significantly negative. In

Company	Const.	Price (+)	Turnover (-)	Volatility (+)	Spread (+)	Percent classified correctly	Mcfadden R ²
Telekomunikasi Indonesia	-10.8057* (-1.905)	1.5016** (1.985)	-0.1206 (-0.6648)	0.2105 (1.271)	0.5845** (2.062)	87.0	0.006920
Bumi Resources	-2.2437* (-1.788)	2.1971** (2.107)	0.0561 (0.428)	-0.2746* (-1.676)	2.2404** (2.125)	85.4	0.010461
Petronas Chemical Group	-2.0974** (-2.132)	0.7125** (2.127)	-0.0655 (-0.833)	0.1801** (2.203)	0.0275 (0.341)	80.3	0.004329
Press Metal Aluminium Hold.	0.3091 (0.276)	0.3094 (0.788)	0.0839 (1.027)	0.1939*** (2.688)	0.1223 (1.571)	79.4	0.006261
Sime Darby Plantation	-2.6355*** (-3.272)	1.0324*** (6.240)	0.0024 (0.048)	-0.1781** (-1.987)	0.1937** (2.052)	82.7	0.026188
IHH Healthcare	-0.0063 (-0.003)	1.0634 (1.253)	0.2307** (2.027)	0.0359 (0.267)	0.2631** (2.198)	83.8	0.012146

Notes: The table shows the results of the binomial logistic regression model (1). The dependent variable is a binary variable, which takes the value 1 if the last digit of the closing price on day t is zero and 0 otherwise. The independent variables are the log of the closing level in day t (*price*), the log of number of stocks (in thousands) traded in day t scaled by the number of outstanding shares (*turnover*), the log of the standard deviation of the stock's daily returns in the previous 5 days (*volatility*), and the log of relative bid-ask spread in day t (*spread*). The expected sign of the coefficients according to the price negotiation hypothesis and the resolution hypotheses is indicated near the name of the independent variables. *Z*-statistics in parenthesis. *significance at the 10% level, **significance at the 5% level, ***significance at the 1% level

Source: Own elaboration

Table 6. Determinants of Islamic stocks in digit zero

theory, return volatility should be positively associated with the presence of price clustering. In fact, more volatile stocks have been found to exhibit higher levels of price clustering in the markets of Australia, Japan and China, for example (Aitken *et al.*, 1996; Ohta, 2006; Hu *et al.*, 2017). However, as emphasized by Narayan *et al.* (2011), the empirical relationship between return volatility and price clustering seems to be sample-specific, as several empirical studies also document a negative association between the two variables. For example, Narayan *et al.* (2011) conclude that, in the case of Mexican stocks, the degree of price clustering tends to decline as volatility increases. This negative impact of market volatility on price clustering has also been reported in the stock markets of Hong Kong and Turkey, for example (Ahn *et al.*, 2005; Booth and Yuksel, 2006). Our results regarding this variable support the idea that the empirical effect of volatility on the price clustering phenomenon varies from security to security.

Variations over time in the costs of trading were captured by the variable relative bid-ask spread. According to the negotiation hypothesis, an increase in the bid-ask spread is expected to be associated with an increase in the tendency of investors to prefer prices ending in zero. This appears to be the case, at statistically significant levels, in four of the securities under analysis (Telekomunikasi Indonesia, Bumi Resources, Sime Darby Plantation and IHH Healthcare). These results lend support to the negotiation hypothesis.

In summary, our results indicate that the attraction hypothesis exhibits only a mild explanatory power on the incidence of price clustering and that cultural factors do not seem to explain the phenomenon. Moreover, the finding that the variables turnover and volatility have, in some cases, an impact on the likelihood of price clustering that goes against the predictions of the resolution hypothesis puts into question the explanatory power of this hypothesis. Finally, the fact that the variables price level and bid-ask spread present a positive and statistically significant coefficient in most stocks suggests that investors tend to exhibit a greater preference to trade at round prices when the costs of this behavior are less significant. These findings provide support for the negotiation hypothesis.

5. Conclusions

This paper documents for the first time the extent of price clustering in a selection of Islamic stocks listed in Indonesia, Malaysia and Pakistan and also investigates the determinants of the phenomenon at the firm level. Our results show that half of the stocks under analysis exhibited significant price clustering. The effect produced an abnormally high accumulation of prices ending in digit zero. In the stocks that displayed signs of price clustering, the frequency of prices ending in digit zero ranged from 12.85% to 20.61%, when one would expect to observe frequencies around 10% if prices were evenly distributed.

Presumably, Muslim investors are more prone to invest in Islamic stocks than non-Islamic stocks because the former are in accord with the principles of Sharia. Since those stocks comply with Islamic law, which leads to avoiding speculation and unnecessary risk-taking, one might expect the pricing of those assets to be less affected by behavioral factors. However, we show that at least some of the Islamic stocks' prices are influenced by investors' preference for round numbers, which is consistent with the idea that some behavioral characteristics of investors are human attributes irrespective of their religion.

Moreover, given that four of the six assets whose prices are not evenly distributed belong to the same market (Malaysia), the results suggest that local factors, related to the national market in which the stocks are traded, may be important in the prevalence of clustering in addition to the specific characteristics of the companies. In fact, our results suggest the presence of different dynamics in each national market concerning the intensity of the

phenomenon: while price clustering seems to become stronger over time in the stocks listed on the Malaysian stock market, it seems to weaken in the stocks traded in Indonesia.

We observe a significant accumulation of prices ending in zero or five in most assets under scrutiny. This prediction is in agreement with the attraction hypothesis. However, the predictions of this hypothesis are not confirmed regarding the prevalence of prices ending in digits one and nine. Thus, our results are only partially explained by the attraction hypothesis. On the other hand, cultural theories about price clustering posit that prices ending in digit seven, given the special symbolism of this digit in the context of Islamic countries, should be anomalously frequent. This prediction was not supported by our results. The multivariate analysis indicates that the sign of the impact of the variables turnover and return volatility on the incidence of price clustering varies from stock to stock. These results are inconsistent with the resolution hypothesis. Finally, the variables price level and bid-ask spread show a significantly positive coefficient in most stocks, which indicates that investors tend to exhibit a greater preference to trade at round prices when the costs of this behavior are less significant. These findings provide support for the negotiation hypothesis.

The presence of price clustering in some of the Islamic stocks under scrutiny carries important theoretical and practical implications. In theory, the existence of significant levels of clustering in some stocks is difficult to reconcile with the EMH and indicates that the informativeness of those assets' prices is impaired. This assessment is particularly applicable to the case of the Islamic stocks of Malaysia since all the assets listed in this market that were analyzed in the present study exhibited significant levels of price clustering. Moreover, the intensity of the phenomenon in Malaysia seems to have increased over time.

Our results are also of interest to market practitioners since price clustering creates patterns of predictability in financial prices. In fact, investors' preference for round prices tends to lead them to create an abnormally high (low) buy-sell imbalance when stock prices are one tick below (above) a round number. This creates a short-term buying (selling) pressure for stocks that are priced one tick below (above) a round price. Thus, our results suggest that, at least in theory, it is possible to devise strategies based on the precise timing of high-frequency trades to take advantage of price clustering in Islamic stocks.

Further research on this topic may include a comparison between the intensity of clustering observed in Islamic and non-Islamic stocks; examining the returns produced by a strategy aimed at exploiting the price clustering effect in Islamic stocks; and investigating the relationship between the levels of price clustering observed in Islamic stocks and other signs of market inefficiency, such as seasonal anomalies, for example.

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